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## Documents

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| **Abstract/Abridgement** | Document | 3.1 Kb | |
| **Complete Specification** | Document | 1791.8 Kb | View as PDF |

**Applicant / Patentee:** (71) MOLDFLOW PTY LTD . 259-261 Colchester Road, kilsyth, Victoria 3137, Australia

**Contact :** (74) JAMES & WELLS . Level 12, KPMG Centre, 85 Alexandra Street, Hamilton, New Zealand

**Service Address :** As above

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## Related Patents

No Related Patents found

## Objections / Hearings

There are no current objections or hearings present

## Renewal Interest

COMPUTER PATENT ANNUITIES PO Box 778, Jersey, JE1 1BL, Channel Islands

## Applicant / Patentee & Licensee History

No applicants nor licensees on record or public access is restricted

## Inventors (72)

Yu, Hua Gang

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## Your Selection Criteria

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# METHOD FOR MODELLING THREE DIMENSIONAL OBJECTS AND SIMULATION OF FLUID FLOW

This invention relates to a method for modelling solid objects, particularly for use in the simulation of fluid flow, to be used for example to simulate prototypes before production In a preferred embodiment the method is used in the design of articles to be manufactured by injection molding, preferably from molten plastic materials.

The modelling of solid objects is employed in various fields Such modelling is used, for example, in the simulation of injection molding. In that field, it is widely recognized that the filling and packing phases of injection molding have a significant effect on the visual and mechanical properties of a molded object Simulation is employed to analyse proposed shapes and injection points, and thus the final quality of the ultimate article. A requirement of any injection mold is that it can be filled with molten polymer given the pressure limits of a real injection molding machine. Simulation can provide information as to whether the mold can be filled and the fill pattern that will be achieved. By using simulation, it is possible to determine optimum gate locations and processing conditions. It is possible to predict the location of weld lines and air traps. Economic benefit is derived from simulation because problems can be predicted and solutions tested prior to the actual creation of the mold This eliminates costly re-working and decreases the time required to get an object into production.

Simulation technology has been developed and generally uses finite element/finite difference techniques to solve the governing equations of fluid flow and heat transfer In order to minimize the time required for analysis and hence the required computer resources, the Hele-Shaw approximation is invoked to simplify the governing

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1 A method for simulating fluid flow within a three dimensional object having first and second generally opposed surfaces including:

matching each element of said first surface with an element of said second surface between which a reasonable thickness may be defined, wherein matched elements of said first surface constitute a first set of matched elements and matched elements of said second surface constitute a second set of matched elements,

specifying a fluid injection point,

performing a flow analysis using each set of said matched elements, whereby said injection point is linked to all locations on said first and second surfaces from which flow may emanate such that resulting flow fronts along said first and second surfaces are synchronized.

2. A method as claimed in claim 1 wherein said injection point is first linked to all said locations from substantially the commencement of said flow analysis

3. A method as claimed in either claim 1 or 2 wherein said injection point remains linked to all said locations at substantially all times in said flow analysis subsequent to being first so linked

4. A method as claimed in any one of the preceding claims wherein said injection point is one of a plurality of injection points.

5 A method as claimed in any one of the preceding claims wherein said synchronization of said flow fronts is checked periodically.

6. A method as claimed in claim 5 wherein said checking is performed at each time step.

7 A method as claimed in any one of the preceding claims wherein said flow fronts are synchronized if found not to be or no longer to be synchronized.

8 A method as claimed in any one of the preceding claims wherein said first and second generally opposed surfaces are one of a plurality of pairs of generally opposed surfaces

9. A method as claimed in any one of the preceding claims wherein any unmatched elements of said first and second surfaces, being elements that could not be matched, are assigned thicknesses being the average of the thicknesses of adjacent matched elements where such adjacent matched elements exist, or of adjacent unmatched elements where such adjacent matched elements do not exist and said adjacent unmatched elements have been assigned thicknesses.

10 A method as claimed in claim 9 wherein each element of an edge surface, being a surface between said first and second surfaces, and adjacent to either of said first or second surface is assigned a thickness proportional to the thickness of the element of said first or second surface to which said element of said edge surface is adjacent.

11. A method as claimed in claim 10 wherein each said element of an edge surface is assigned a thickness between 0.5 and 1.5 times said thickness of the element of said first or second surface to which said element of said edge surface is adjacent.

12 A method as claimed in claim 11 wherein each said element of an edge surface is assigned a thickness between 0.7 and 0.9 times said thickness of the element of said first or second surface to which said element of said edge surface is adjacent.

13. A method as claimed in claim 12 wherein each said element of an edge surface is assigned a thickness approximately 0.75 times said thickness of the element of said first or second surface to which said element of said edge surface is adjacent.

14. A method as claimed in claim 10 wherein each element of an edge surface not adjacent to said first or second surface is assigned a thickness being the average of the thicknesses of adjacent elements of said edge surface that have been assigned thicknesses

15. A method as claimed in any one of the preceding claims wherein flow is simulated at a rate directly proportional to a desired flow rate for the object.

16. A method as claimed in claim 15 wherein said rate is proportional to the ratio of computational domain volume of said object to real volume of said object.

17. A method as claimed in claim 16 wherein said rate is substantially equal to the ratio of said computational domain volume to said real volume.

18. A method as claimed in any one of the preceding claims wherein said method is performed with first and second representations of said first and second surfaces respectively comprising first and second meshes or lattices respectively, wherein said elements are interstices of said first and second meshes or lattices.

19. A method as claimed in any one of the preceding claims wherein said elements are triangular.

20. A method as claimed in any one of claims 1 to 18 wherein said elements are quadrilateral.

21 A method as claimed in claim 19 wherein said elements are substantially equilateral.

22. A method as claimed in claim 18 wherein said method includes creating said first and second representations.

23. A method as claimed in either claim 18 or 22 wherein said method includes creating improved representations of said first and second surfaces, whereby said elements are elements of said improved representations and said method is performed with said improved representations.

24. A method as claimed in claim 18 wherein said first and second representations are, or are a part of, a representation or representations for stereolithography of said object.

25. A method as claimed in any one of the preceding claims wherein said method is performed by a computer running a computer program encoding said method for simulating fluid flow.

26. A method as claimed in any one of the preceding claims wherein said method includes corrections for non-isothermal temperature fields and/or non-Newtonian fluids.

27. A method for simulating fluid flow within a three dimensional object having first and second generally opposed surfaces including:

providing or creating first and second representations of said first and second surfaces respectively,

creating first and second improved representations from said first and second representations respectively,

matching each element of said first improved

representation of said first surface with an element of said second improved representation of said second surface between which a reasonable thickness may be defined, wherein matched elements of said first improved representation constitute a first set of matched elements and matched elements of said second improved representation constitute a second set of matched elements,

specifying a fluid injection point,

performing a flow analysis using each set of said matched elements, whereby said injection point is linked to all locations on said first and second improved representations from which flow may emanate such that resulting flow fronts along said first and second improved representations are synchronized

28 A method as claimed in claim 27 wherein said first and second representations are, or are a part of, a representation or representations for stereolithography of said object.

29. A method as claimed in either claim 27 or 28 wherein said first and second improved representations comprise small equilateral triangular elements.

30. A method for simulating fluid flow within a three dimensional object having first and second generally opposed surfaces including:

matching each element of said first surface with an element of said second surface between which a reasonable thickness may be defined, wherein matched elements of said first surface constitute a first set of matched elements and matched elements of said second surface constitute a second set of matched elements and said elements are substantially equilateral triangles,

specifying a fluid injection point,

performing a flow analysis using each set of said matched elements, whereby said injection point is linked to

all locations on said first and second surfaces from which flow may emanate such that resulting flow fronts along said first and second surfaces are synchronized, wherein said first and second representations are, or are a part of, a representation or representations for stereolithography of said object.

31. A method as claimed in claim 30 wherein said injection point is one of a plurality of injection points.

32 A computing device provided with or running a computer program encoding a method for simulating fluid flow as claimed in any one of the preceding claims.

33. A computer storage medium provided with a computer program embodying a method for simulating fluid flow as claimed in any one of claims 1 to 31.

34 A method for modelling a three dimensional object including:

specifying first and second generally opposed surfaces of said object,

forming first and second representations of said first and second surfaces respectively, wherein said first and second representations each comprise a plurality of elements,

matching pairs of elements of said first and second surfaces between which a reasonable thickness may be defined.

35. A method as claimed in claim 34 wherein said first and second representations comprise first and second meshes or lattices respectively, wherein said elements are interstices of said first and second meshes or lattices.

36. A method as claimed in either claim 34 or 35 wherein said elements are triangular.

37 A method as claimed in claim 36 wherein said elements are substantially equilateral.

38. A method as claimed in claim 34 wherein said elements are quadrilateral.

39 A method as claimed in any one of claims 34 to 38 wherein each element of each of said matched pairs of elements is assigned respectively said thickness.

40 A method as claimed in claim 39 wherein unmatched elements of said first and second surfaces are assigned thicknesses being the average of the thicknesses of surrounding, matched elements of said first and second surfaces.

41 A method as claimed in claim 40 wherein any unmatched elements of said first and second surfaces, being elements that could not be matched, are assigned thicknesses being the average of the thicknesses of adjacent matched elements where such adjacent matched elements exist, or of adjacent unmatched elements where such adjacent matched elements do not exist and said adjacent unmatched elements have been assigned thicknesses.

42. A method as claimed in claim 41 wherein each element of an edge surface, being a surface between said first and second surfaces, and adjacent to either of said first or second surface is assigned a thickness proportional to the thickness of the element of said first or second surface to which said element of said edge surface is adjacent

43. A method as claimed in claim 42 wherein each said element of an edge surface is assigned a thickness between 0.5 and 1.5 times said thickness of the element of said first or second surface to which said element of said edge

surface is adjacent

44. A method as claimed in claim 43 wherein each said element of an edge surface is assigned a thickness between 0.7 and 0.9 times said thickness of the element of said first or second surface to which said element of said edge surface is adjacent.

45. A method as claimed in claim 44 wherein each said element of an edge surface is assigned a thickness 0.75 times said thickness of the element of said first or second surface to which said element of said edge surface is adjacent.

46. A method as claimed in claim 42 wherein each element of an edge surface not adjacent to said first or second surface is assigned a thickness being the average of the thicknesses of adjacent elements of said edge surface that have been assigned thicknesses.

47 A method for simulating fluid flow within a three dimensional object having first and second generally opposed surfaces including:

matching each element of said first surface with an element of said second surface between which a reasonable thickness may be defined, wherein matched elements of said first surface constitute a first set of matched elements and matched elements of said second surface constitute a second set of matched elements,

specifying a fluid injection point,

performing a flow analysis using each set of said matched elements, and

synchronizing flow fronts resulting from said flow analysis along said first and second surfaces.

48. A method as claimed in claim 47 wherein said flow fronts are synchronized from substantially the commencement

of said flow analysis.

49 A method as claimed in claim 47 wherein said flow fronts are first synchronized after the commencement of said flow analysis.

50. A method as claimed in any one of claims 47 to 49 wherein said injection point remains linked to all said locations at substantially all times in said flow analysis subsequent to being first so linked.

51. A method as claimed in any one of claims 47 to 50 wherein said injection point is one of a plurality of injection points.

52 A method as claimed in any one of claims 47 to 51 wherein said synchronization of said flow fronts is checked periodically.

53. A method as claimed in claim 52 wherein said checking is performed at each time step.

54. A method as claimed in any one of claims 47 to 53 wherein said flow fronts are synchronized if found not to be or no longer to be synchronized.

55. A method as claimed in any one of claims 47 to 54 wherein said first and second generally opposed surfaces are one of a plurality of pairs of generally opposed surfaces.

56. A method as claimed in any one of claims 47 to 55 wherein any unmatched elements of said first and second surfaces, being elements that could not be matched, are assigned thicknesses being the average of the thicknesses of adjacent matched elements where such adjacent matched elements exist, or of adjacent unmatched elements where

such adjacent matched elements do not exist and said adjacent unmatched elements have been assigned thicknesses

57. A method as claimed in claim 56 wherein each element of an edge surface, being a surface between said first and second surfaces, and adjacent to either of said first or second surface is assigned a thickness proportional to the thickness of the element of said first or second surface to which said element of said edge surface is adjacent

58. A method as claimed in claim 57 wherein each said element of an edge surface is assigned a thickness between 0.5 and 1.5 times said thickness of the element of said first or second surface to which said element of said edge surface is adjacent.

59. A method as claimed in claim 58 wherein each said element of an edge surface is assigned a thickness between 0.7 and 0.9 times said thickness of the element of said first or second surface to which said element of said edge surface is adjacent.

60 A method as claimed in claim 59 wherein preferably each said element of an edge surface is assigned a thickness approximately 0.75 times said thickness of the element of said first or second surface to which said element of said edge surface is adjacent.

61. A method as claimed in claim 60 wherein each element of an edge surface not adjacent to said first or second surface is assigned a thickness being the average of the thicknesses of adjacent elements of said edge surface that have been assigned thicknesses.

62. A method as claimed in any one of claims 47 to 61 wherein flow is simulated at a rate directly proportional to a desired flow rate for the object.

63. A method as claimed in claim 62 wherein said rate is proportional to the ratio of computational domain volume of said object to real volume of said object.

64. A method as claimed in claim 63 wherein said rate is substantially equal to the ratio of said computational domain volume to said real volume.

65. A method as claimed in any one of claims 47 to 64 wherein said method is performed with first and second representations of said first and second surfaces respectively comprising first and second meshes or lattices respectively, wherein said elements are interstices of said first and second meshes or lattices.

66. A method as claimed in any one of claims 47 to 65 wherein said elements are triangular.

67. A method as claimed in any one of claims 47 to 65 wherein said elements are quadrilateral.

68. A method as claimed in claim 66 wherein said elements are substantially equilateral.

69. A method as claimed in claim 65 wherein said method includes creating said first and second representations.

70. A method as claimed in claim 65 wherein said method includes creating improved representations of said first and second surfaces, whereby said elements are elements of said improved representations and said method is performed with said improved representations.

71. A method as claimed in claim 65 wherein said first and second representations are, or are a part of, a representation or representations for stereolithography of

said object

72 A method as claimed in any one of claims 47 to 71 wherein said method includes corrections for non-isothermal temperature fields and/or non-Newtonian fluids.

73 A method as claimed in any one of claims 47 to 72 wherein said method is performed by a computer running a computer program encoding said method for simulating fluid flow.

74 A method for simulating fluid flow within a three dimensio 1 object having first and second generally opposed surfaces including·

matching each element of said first surface with an element of said second surface between which a reasonable thickness may be defined, wherein matched elements of said first surface constitute a first set of matched elements and matched elements of said second surface constitute a second set of matched elements,

specifying a fluid injection point,

performing a flow analysis using said first set of matched elements,

adapting said flow analysis to said second set of matched elements, and

synchronizing flow fronts resulting from said flow analysis and said adaptation of said flow analysis along said first and second surfaces.

75. A method as claimed in claim 74 wherein said method is performed with first and second representations of said first and second surfaces respectively comprising first and second meshes or lattices respectively, wherein said elements are interstices of said first and second meshes or lattices.

76. A method as claimed in either claim 74 or 75 wherein

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said elements are triangular.

77. A method as claimed in either claim 74 or 75 wherein said elements are quadrilateral.

78. A method as claimed in claim 76 wherein said elements are substantially equilateral.

79. A method as claimed in any one of claims 74 to 78 wherein said method includes creating said first and second representations.

80. A method as claimed in any one of claims 74 to 79 wherein said method includes creating improved representations of said first and second surfaces, whereby said elements are elements of said improved representations and said method is performed with said improved representations

81. A method as claimed in any one of claims 1, 27 or 47 wherein said synchronization comprises matching pressure and temperature.

END